Physics 10164 - Exam 1B

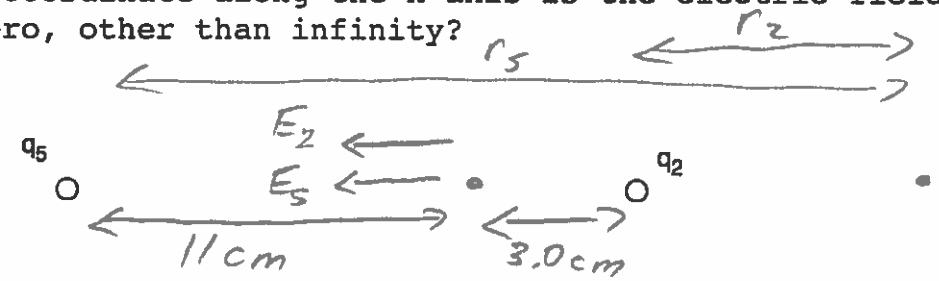
Partial credit will be given provided you show all work and are solving parts of the problem correctly. Points will be deducted if you don't show your work even if you get the right answer. Clearly indicate your answer with a circle or a box and remember to include correct units and significant figures.

1. (35 pts) Charge q_5 = -5.00 nC and is located at the origin. Charge q_2 = +2.00 nC and is located at x = 14.0 cm.

a) Find the magnitude and direction of the electric field at the location x = 11.0 cm.

b) What is the magnitude and direction of the acceleration felt by an electron at x = 11.0 cm due to this electric field?

c) At what x-coordinate along the x-axis is the electric field equal to zero, other than infinity?



a) $|E_{TOT}| = -|E_2| - |E_5| = -\frac{(9\times10^9)(2\times10^{-9})}{.03^2} - \frac{(9\times10^9)(5\times10^{-9})}{.11^2}$

$= -20000 - 3720 = -23700$

or $\boxed{23700\ V/m,\ -x\ dir}$

b) F_E points in +x dir since ⊖ charge + $\vec{E}$ points −x

$F_E = qE = ma \Rightarrow a = \frac{qE}{m} = \frac{(1.6\times10^{-19})(23700)}{9.11\times10^{-31}}$

$= \boxed{4.16\times10^{15}\ m/s^2,\ +x}$

c) $|E_5| = |E_2|$

$\frac{\cancel{k}\, q_5}{r_5^2} = \frac{\cancel{k}\, q_2}{r_2^2}$

$\frac{q_5}{q_2} = \frac{r_5^2}{(r_5 - .14)^2}$

$\sqrt{2.5} = \frac{r_5}{r_5 - .14}$

$1.58 r_5 - .2214 = r_5$

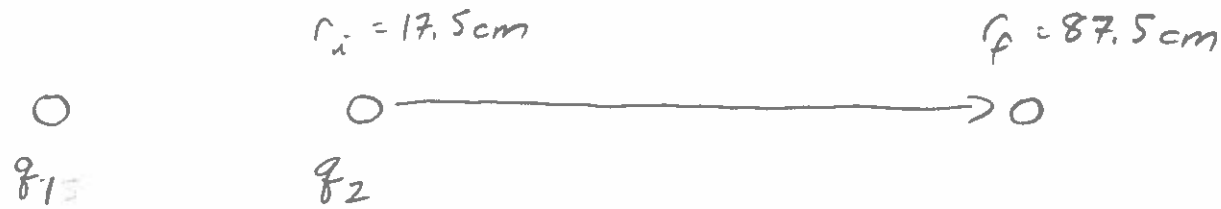
$0.58 r_5 = .2214$

$\boxed{r_5 = 0.382\ m}$ or 38.2 cm

2. (35 pts) A -75.0 μC charge is located at the origin and fixed in place. A 22.0-gram mass with a charge of -135 μC is located at x = 17.5 cm and initially at rest. An experimenter picks up the mass and places it at x = 87.5 cm. You may assume that the electric force and the applied force of the experimenter are the only relevant forces here.

a) How much work is done by the experimenter?

b) If the experimenter did not intervene and simply allowed the mass to accelerate on its own in response to the electric force, how fast would the mass be moving at x = 87.5 cm?



$$\Sigma W_F = W_E + W_{App} = 0$$

$$W_E = -q_2 \Delta V_1 = -(-135\times10^{-6})(V_f - V_i)$$

$$= (135\times10^{-6})\left(\frac{k_c(-75\times10^{-6})}{.875} - \frac{k_c(-75\times10^{-6})}{.175}\right)$$

$$= (135\times10^{-6})(-771429 - (-3857142))$$

$$= 417\ \text{J}, \text{ so } \boxed{W_{App} = -417\ \text{J}}$$

b) $\Sigma W_F = W_E = \Delta K$

$$417 = \tfrac{1}{2}(.022)v^2$$

$$\boxed{v = 195\ \text{m/s}}$$

#3. (30 pts) A 35.0 μF capacitor and a 15.0 Ohm resistor are connected in series with a 12.0-Volt battery. At t = 0, a switch is closed, and the capacitor begins to charge. Answer each part with 3 SF.

a) After two time constants have elapsed, what is the voltage drop across the capacitor?
b) After two time constants have elapsed, what is the voltage drop across the resistor?
c) At what time is the current equal to 3.20% of its maximum possible value?
d) How many time constants is the value you got for (c)?

a) $\Delta V_c = \frac{Q}{C} = \frac{C\mathcal{E}(1-e^{-t/\tau})}{C} = \mathcal{E}(1-e^{-2})$

$\Delta V_c = 12(1-e^{-2}) = 12(.865) = \boxed{10.4 \text{ Volts}}$

b) Loop rule $\Delta V_c + \Delta V_R = 12$

$\boxed{\Delta V_R = 1.62 \text{ Volts}}$

c) $I(t) = I_{max} e^{-t/\tau}$

$.032 = e^{-t/\tau}$

$\ln .032 = -\frac{t}{RC}$

$-3.442 = -\frac{t}{RC}$

$t = 3.442 RC = \boxed{.00181 \text{ s}}$

d) $\tau = RC = .000525$

$\frac{t}{\tau} = \frac{.00181}{.000525} = \boxed{3.44 \text{ time constants}}$